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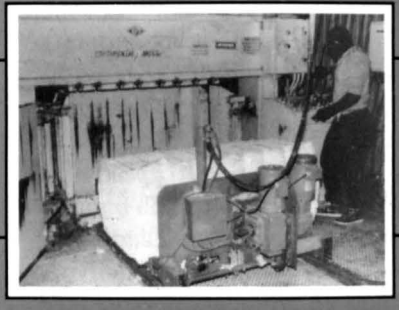

Measuring the Effect of Louisiana Agriculture on the State Economy Through Multiplier and Impact Analysis

By David W. Hughes

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By David W. Hughes[1]

INTRODUCTION

The strength of any regional economy is determined by the economic health of the sectors making up that economy. Especially important are industries that form the economic base. By definition, basic industries attract outside dollars into the economy of a region through export sales of goods and services, which directly stimulate employment and income in the industries making the sales. Further, exports indirectly stimulate economic activity in other industries of the regional economy that supply inputs to the exporting firm.

Louisiana agriculture serves as an example of a basic industry for the state economy. Agriculture makes substantial contributions to state economic activity in terms of generating employment, income, and sales. Economic activity directly tied to agricultural production and processing (*direct effect*) shows only part of its contribution to the state economy, however. Producers and processors of agricultural products make purchases from a variety of other types of firms located in the state and located elsewhere. Affected Louisiana firms, in turn, buy products from additional state firms that result in additional sales (an *indirect effect*). Agricultural producers and processors also make payments to workers that support spending by households on Louisiana products, thus setting off further rounds of economic activity that together form the *induced effect*. The sum of the direct, indirect, and induced effects provides an estimate of the total impact or multiplier effect of dollars injected by agriculture into other sectors of the economy.[2]

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[2]Spending by firms and consumers on goods and services produced elsewhere are leakages out of the state economy that generate no multiplier effect. The greater the leakages, the lower the multiplier effect.

INPUT-OUTPUT MODEL VALIDATION AND INTERPRETATION

Model Interpretation

Input-Output (I-O) analysis is commonly used by economists to measure the total impact of economic activity in a given sector of an economy. I-O models characterize economic linkages (sales and purchases) between all industries as well as between industries and other agents, such as households and government, in a formalized framework. As such, I-O analysis is especially useful in looking at the structure of a regional economy and the secondary effects that may spin off from an initial change in economic activity.[3]

Input-output models are often used to generate various economic multipliers, the most basic being output or sales multipliers. In an input-output table, output or sales multipliers are the dollar change in output for all industries in a given economy for a dollar change in sales for a particular industry. For example, assume a given agricultural industry increases its sales by one dollar. Further assume that one dollar increase causes an eventual additional increase of $1.50 in output for the entire economy. The total sales multiplier for that agricultural industry will be $2.50 or the one dollar direct effect plus the $1.50 in spending, the indirect effect, that has been created by the direct effect.

There are two categories of sales multipliers generated from any input-output table. So-called Type I sales multipliers include the direct effect of a dollar change in output for a given industry plus the indirect effect of that change on the production of all other firms in the regional economy. Excluded from the Type I sales multiplier are any of the effects of changes in worker income and household spending as industry output changes. So-called Type II or Type III sales multipliers include the induced effect or changes in household income and spending as industry output changes. Hence, a Type III sales multiplier of $3.00 would include the one dollar direct effect and could include a $1.50 indirect effect and an additional $0.50 induced effect. The latter occurs purely because of changes in household income and expenditures as industry output changes.

Several caveats are in order concerning the interpretation and use of multipliers from any input-output model. First, input-output multipliers are reported on a per unit basis. As such, the multipliers do not indicate the total contribution of the industry in question to the regional economy. For example, a sector such as Fruits could have a large Type III sales

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[3]A discussion of the basic concepts of input-output analysis can be found in Appendix One.

multiplier. However, the total contribution of the industry to the Louisiana economy would be smaller than the contribution of a sector such as Sugarcane, which might have a smaller sales multiplier.

Further, input-output multipliers do not speak to the profitability and hence the long run viability of an industry. A sector could have large employment and output multipliers, indicating strong linkages with other firms in the regional economy. Yet, the same sector could be unprofitable. In such a situation, the future viability of that industry is questionable despite the large multipliers.

Input-output multipliers should be interpreted as upper bound estimates of the actual change in economic activity rather than an estimate of the change in economic activity itself. This interpretation holds because static I-O models are based on several rather restrictive assumptions. Firms in a given industry are aggregated into homogenous groups that have the same mix of inputs and outputs. Economies and diseconomies of size and input substitution in industry production are ruled out even if relative input prices change.[4] Thus farm firms would not, for example, decrease their use of petroleum and increase their use of other inputs if the price of petroleum increased faster than other input prices. Idle capacity is assumed to exist in each industry. Because of these assumptions, primary factors of production and other inputs are readily available at constant per unit costs, that is, average costs do not change with changes in output. Further, changes in employment are assumed to not effect regional labor markets. For example, a worker suffering a job loss because of a sugar mill closure is implicitly assumed to leave the state rather than find alternative employment in Louisiana. The assumption is especially important because household spending supported by that employment is also now assumed to occur elsewhere.

Further, so-called forward linked effects are not accounted for by the multiplier estimates derived from I-O models. Forward linkages represent a given industry's sales to other industries. For example, agriculture is "forward linked" to (provides inputs for or makes sales to) food processing. A forward linked effect for production agriculture would be increases in agricultural processing occurring because of an increase in the output of production agriculture. But any effects on regional processing activity with forward linkages to agricultural activity would not be accounted for by the sales multiplier for agriculture.

Input-output multipliers for a given sector account for the purchases that the sector makes from other industries or so-called backward linked effects. For example, a farm commodity may have significant backward linked effects, such as purchases of seed, fertilizer, and other inputs and spending by farm households. Such backward linked effects are ac-

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[4]For economists, these properties mean that firms are assumed to have fixed proportion production functions that are homogenous of degree one.

counted for in the input-output multiplier for that commodity. Thus, multipliers indicate the strength of backward linkages with the rest of the regional economy. As a result, in examining the impact of production agriculture, it is imperative to estimate multiplier effects beginning with any processing activity that has limited alternatives to regional agricultural firms as a source of raw material inputs.

Model Validation

The IMpact analysis for PLANing (IMPLAN) model building system (Alward et al.) was used to construct a preliminary I-O model of the Louisiana economy. The model was then improved in a number of ways through the application of relevant information and data sources concerning economic linkages in Louisiana. In particular, unpublished data provided by the Louisiana Department of Employment Security were used to improve accuracy in the IMPLAN model. As explained below, data especially relevant to agriculture were also used in improving model accuracy. This process resulted in what is termed a hybrid model. For more information on hybrid models in general and the construction of the Louisiana hybrid input-output model see Appendix Two.

Major structural changes in farming and in food processing between 1985 and 1994 could limit the validity of model results for the current Louisiana economy. Model validity was upheld by using more current information concerning the production technology for a number of production agriculture and food processing sectors. Analysis of published aggregate values implied that, at least in terms of aggregate employment, major structural changes in food processing and in farming were limited. For example, food processing employment in Louisiana was estimated at 21,561 workers in the third quarter of 1985 and at 21,600 workers in March of 1994 (Louisiana Department of Labor 1987, 1994). Total farm-related employment in 1985 was estimated at 68,960 in 1985 and 62,085 in 1992 (U.S. Department of Commerce).

Model accuracy was improved by the use of more recent data, from 1985 through 1989 published by Zapata and Frank (1992), in estimating gross industry output for farming and for selected food processing sectors. Recent crop and processing production functions, published in 1990 by the Department of Agricultural Economics and Agribusiness (a unit of the Louisiana State University Agricultural Center), were used in estimating model coefficients for production agriculture sectors and selected food processing sectors. The use of more recent production functions helps account for technical change that has occurred in the production and processing of agricultural products. For more details on the model updating procedure see Appendix Two.

MODEL RESULTS

Basic Structure of the Louisiana Economy

A description of the basic structure of the Louisiana economy in 1985 provides an overview concerning where agriculture fits into the overall picture. Numbers presented in this section understate the actual contribution of agriculture, in that only its direct contribution is discussed.

Total Industry Output (TIO) is the total value of sales by all industries in the Louisiana economy. Based on estimates from the hybrid IMPLAN model, TIO in the Louisiana economy was estimated at $142.397 billion in 1985 (Table 1). Gross State Product (GSP) is the total value of returns to owners of the primary factors of production, namely owners of labor and capital (who may reside in Louisiana or elsewhere), plus indirect business taxes. It is also the state level equivalent to Gross Domestic Product at the national level. GSP is calculated as the difference between the total value of sales by a given sector and all products consumed in the production process (intermediate products). It is a better measure of the value added to commodities than TIO by a given sector because it eliminates the double counting of intermediate products. GSP for Louisiana was estimated at $74.017 billion in 1985 in the Louisiana hybrid input-output model. Total employment in the Louisiana economy was estimated at 1,984,043 jobs in 1985.

The economic structure of the Louisiana economy in broad terms can be seen in Figure 1. Included in the figure is the distribution of economic activity in Louisiana by five major categories in terms of GSP and employment. In total, farming, food processing, and fisheries were directly responsible for $2.619 billion or 4% of GSP and 6% of all jobs in Louisiana.

All services, including government, transportation and public utilities, financial services, and all other services were responsible for the majority of employment and GSP in the Louisiana economy in 1985 (Figure 1). Employment in Services was concentrated in Retail Trade not Restaurants, at 238,696 jobs, Health Services, and Educational Services sectors among others (Table 1).

Mining, mainly in the oil and natural gas mining sector, was the second largest contributor among the five major categories to GSP at $15.699 billion in 1985 (Figure 1). There were also 93,701 jobs in mining at that time. The importance of oil and natural gas can also been seen in its contribution to the manufacturing sector through the various petrochemical industries.

Manufacturing other than the processing of food and other agricultural inputs was responsible for 6% of employment and 11% of GSP of

Table 1. Composition of the Louisiana Economy by Major Industry Group in 1985

Industry Number and Name	Total Industry Output (TIO)	Gross State Product (GSP)	Total Employment
	(Million 1985 $)		
1 Dairy Farm Products	119.100	59.140	6962
2 Poultry and Eggs	275.154	60.425	5865
3 Cattle	182.181	30.007	2702
4 Other Livestock	67.850	13.789	1302
5 Cotton	243.599	85.257	6415
6 Rice, Other Food Grains	159.628	80.457	5664
7 Feed Grains	74.296	16.825	1521
8 Hay and Pasture	28.825	5.917	529
9 Other Agriculture	11.593	2.796	541
10 Fruits	14.730	8.356	1842
11 Vegetables	34.368	14.303	2351
12 Sugarcane	169.882	93.023	11368
13 Soybeans	238.481	115.129	4955
14 Forestry	127.068	64.572	1344
15 Commercial Fishing	312.921	110.294	5069
16 Agricultural Services	178.197	99.819	8330
17 Metal Mining	17.250	3.217	80
18 Other Nonmetallic Mining	298.003	159.374	3727
19 Oil and Gas Extraction	20895.020	15536.180	89894
20 General Building Construction	4795.174	2036.864	31579
21 Heavy Contract Construction	2347.771	1013.556	56086
22 Repair, Maintenance Construction	1870.732	876.768	57897
23 Fabricated Metal Products	1125.330	490.951	13851
24 Meat Packing, Preparation	160.705	25.630	1244
25 Poultry and Egg Processing	201.944	30.688	1889
26 Milk, Other Processed Dairy	400.379	96.184	2333
27 Processed Fish and Seafood	138.099	25.444	1499
28 Other Canned, Frozen Products	128.431	29.575	963
29 Canned Fruits, Vegetables	74.155	20.976	431
30 Bread and Related Products	257.829	104.549	3486
31 Other Processed Fats, Feed	312.456	58.039	1267
32 Rice Milling	201.656	32.366	1049
33 Sugar Milling and Refining	817.102	143.061	4949
35 Beverages	512.488	144.762	3869
36 Cottonseed Oil Mills	48.785	8.733	157
37 Soybean Oil Mills	65.436	3.231	55
38 Roasted Coffee	503.452	72.075	876
39 Miscellaneous Food Processing	97.108	33.861	1113
40 Textiles	102.888	39.838	1978

Table 1. (continued)

41 Apparels	304.422	106.097	9047
42 Lumber	981.406	334.842	12953
43 Furniture	47.520	17.678	799
44 Paper Products	1665.277	594.432	12311
45 Printing and Publishing	724.834	376.242	10824
46 Chemical Products	6756.720	2075.449	28560
47 Petroleum Refining	21997.130	3593.891	12925
48 Rubber, Miscellaneous Products	162.615	61.639	2030
49 Leather and Tanning	6.480	1.964	183
50 Glass, Stone and Clay	526.427	219.600	6921
51 Primary Metal Products	409.457	133.642	3501
52 Nonelectrical Machinery	817.708	441.213	10058
53 Scientific Instruments	54.116	28.748	884
54 Other Electrical Machinery	1010.494	347.666	8374
55 Motor Vehicles	985.667	247.111	3346
56 Other Transportation Equipment	1247.371	658.285	17186
57 Miscellaneous Manufacturing	127.155	57.359	1555
58 Railroads, Commuter Transportation	629.481	382.820	10010
59 Motor Freight Transport, Warehousing	1141.335	737.330	24429
60 Water Transportation	3464.092	960.631	33857
61 Air Transportation	678.995	318.173	7560
62 Pipe Lines, Not Natural Gas	370.879	210.110	1223
63 Transportation Services	164.775	105.533	3693
64 Communications	1809.871	1249.206	22113
65 Electric, Gas, Sanitary Services	5594.524	2567.689	33212
66 Wholesale Trade	5181.423	3761.047	95148
67 Retail Trade Not Restaurants	6537.766	4126.121	238696
68 Other Finance and Insurance	4488.961	2359.849	102752
69 Real Estate	11182.300	9032.135	25804
70 Hotels and Lodging Places	703.004	449.505	35182
71 Personal Services	1221.084	982.253	54516
72 Repair Services	1400.742	725.183	26750
73 Business Services	2496.375	1885.456	90027
74 Legal Services	1194.518	923.736	21168
75 Miscellaneous Services	1383.006	891.954	28443
76 Eating and Drinking Places	3086.908	1603.180	98622
77 Amusement Services	479.612	246.070	18494
78 Health Services	5676.178	3444.076	180598
79 Educational Services	3632.007	2573.562	159341
80 Membership Organizations	555.374	306.355	8549
81 Social Services	402.162	243.753	35577
82 Government, Special Industry	3487.325	2789.700	139847
Total	142397.500	74017.300	1984043

Note: Sugar milling and sugar refining are reported as a single industry to avoid disclosing proprietary information.

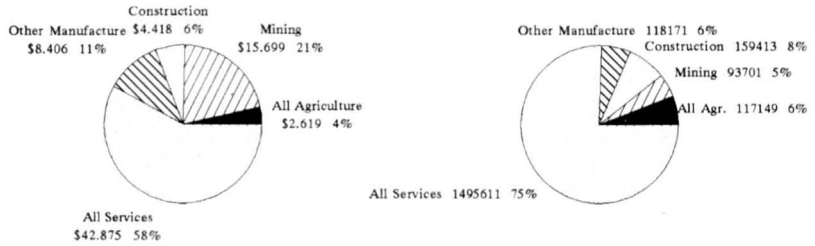

Figure 1. Composition of the Louisiana Economy by Major Category in 1985.

the Louisiana economy in 1985. As shown in Table 1, Chemical Products and Petroleum Refining were together responsible for $28.754 billion in TIO and $5.669 billion in GSP in 1985. Other Transportation Equipment and Nonelectrical Machinery were also important manufacturing sectors in Louisiana in 1985.

Multiplier Analysis for Agricultural Industries

The Louisiana IMPLAN I-O model was used to generate output and employment multipliers for 82 aggregate Louisiana industries as reported in Table 2. Multipliers reported in Table 2 are on a per unit basis. Multipliers reflect the total change in economic activity across all industries for a given change in activity for a particular industry. For example, a one dollar increase in output (total sales) by Rice Milling firms was projected to result in a $1.8578 increase in total economic activity in the state when household spending effects were excluded (the Type I Multiplier). A one dollar increase in sales by Rice Millers was predicted to increase Louisiana economic activity by $2.3748 when the effect of spending by households was included (the Type III Multiplier). A one million dollar increase in total sales by the same sector was expected to increase state employment across all industries by slightly more than 31 jobs.

Employment Multipliers ranged in value from 143 jobs per million dollars of gross sales for Fruits to 5.16 jobs per million dollars of output for Real Estate as shown in Table 2. The unweighted average of employment multipliers for all industries was 30.7973 jobs per million dollars of gross sales. Type I Output Multipliers ranged from $1.054 for

Table 2. Sales, Employment Multipliers for all Aggregate Industries in the Louisiana Economy in 1985

Industry			Sales Type I	Sales Type III	Employment Total
			(1985 $)		
1 Dairy Farm Products	1.4249	2.5726	69.50		
2 Poultry and Eggs			1.7365	2.3175	35.18
3 Cattle			1.7245	2.1712	27.05
4 Other Livestock			1.7507	2.2911	32.73
5 Cotton			1.6517	2.3422	41.81
6 Rice, Other Food Grains			1.4493	2.2389	47.81
7 Feed Grains			1.7968	2.3233	31.89
8 Hay and Pasture			1.7961	2.2792	29.26
9 Other Agriculture			1.8011	2.8534	63.72
10 Fruits			1.4358	3.7978	143.03
11 Vegetables			1.5319	2.8970	82.66
12 Sugarcane			1.4130	2.7353	80.07
13 Oil Bearing Crops			1.5319	2.0684	32.49
14 Forestry			1.4463	1.8306	23.27
15 Commercial Fishing			1.4299	1.8154	23.35
16 Agricultural Services			1.4177	2.3720	57.79
17 Metal Mining			1.5480	1.7445	11.90
18 Other Nonmetallic Mining			1.3533	1.6530	18.15
19 Oil and Gas Extraction			1.1928	1.3038	6.72
20 General Building Construction			1.3343	1.5676	14.13
21 Heavy Contract Construction			1.3671	1.9169	33.30
22 Repair, Maintenance Construction			1.2669	1.9175	39.40
23 Fabricated Metal Products			1.1991	1.4773	16.84
24 Meat Packing, Preparation			1.4132	1.6582	14.83
25 Poultry and Egg Processing			2.3106	2.9075	36.14
26 Milk, Other Processed Dairy			1.6966	2.1237	25.87
27 Processed Fish and Seafood			1.6402	2.0173	22.83
28 Other Canned, Frozen Products			1.5546	1.8227	16.24
29 Canned Fruits, Vegetables			1.3728	1.5849	12.84
30 Bread and Related Products			1.3879	1.7460	21.69
31 Other Processed Fats, Feed			1.6335	1.8301	11.90
32 Rice Milling			1.8578	2.3748	31.31
33 Sugar Milling			2.1342	3.1808	63.38
34 Sugar Refining			1.9312	2.3876	27.64
35 Beverages			1.4130	1.6848	16.46
36 Cottonseed Oil Mills			1.9984	2.4260	25.89
37 Soybean Oil Mills			2.2056	2.5785	22.58
38 Roasted Coffee			1.3839	1.5295	8.82
39 Miscellaneous Food Processing			1.4570	1.7818	19.66
40 Textiles			1.1787	1.5775	24.15

Table 2. (continued)

41 Apparels	1.2170	1.8275	36.97
42 Lumber	1.6871	2.0936	24.61
43 Furniture	1.3068	1.6981	23.70
44 Paper Products	1.4852	1.7166	14.01
45 Printing and Publishing	1.2124	1.5509	20.50
46 Chemical Products	1.6901	1.8731	11.08
47 Petroleum Refining	1.7707	1.8664	5.79
48 Rubber, Miscellaneous Products	1.5929	1.9109	19.26
49 Leather and Tanning	1.3166	1.9159	36.29
50 Glass, Stone and Clay	1.3825	1.7133	20.03
51 Primary Metal Products	1.3979	1.6269	13.86
52 Nonelectrical Machinery	1.1804	1.4543	16.59
53 Scientific Instruments	1.2296	1.5858	21.57
54 Other Electrical Machinery	1.3066	1.5271	13.35
55 Motor Vehicles	1.1452	1.2435	5.95
56 Other Transportation Equipment	1.1912	1.4911	18.16
57 Miscellaneous Manufacturing	1.2652	1.5572	17.68
58 Railroads, Commuter Transportation	1.3673	1.7543	23.44
59 Motor Freight Transport, Warehousing	1.3399	1.8269	29.49
60 Water Transportation	1.8202	2.1638	20.81
61 Air Transportation	1.4551	1.7510	17.92
62 Pipe Lines, Not Natural Gas	1.3919	1.5464	9.36
63 Transportation Services	1.2716	1.7616	29.67
64 Communications	1.2171	1.5158	18.08
65 Electric, Gas, Sanitary Services	1.5907	1.7860	11.83
66 Wholesale Trade	1.2249	1.6331	24.72
67 Retail Trade Not Restaurants	1.3154	2.0532	44.68
68 Other Finance and Insurance	1.3115	1.8378	31.87
69 Real Estate	1.1587	1.2438	5.16
70 Hotels and Lodging Places	1.2813	2.2567	59.07
71 Personal Services	1.1174	1.9513	50.50
72 Repair Services	1.2456	1.6692	25.66
73 Business Services	1.1698	1.8753	42.73
74 Legal Services	1.1674	1.5381	22.45
75 Miscellaneous Services	1.2608	1.7249	28.10
76 Eating and Drinking Places	1.2949	1.9468	39.48
77 Amusement Services	1.3710	2.1964	49.98
78 Health Services	1.2820	1.9246	38.91
79 Educational Services	1.2012	2.0364	50.58
80 Membership Organizations	1.3134	1.6706	21.63
81 Social Services	1.2754	2.9429	100.98
82 Government, Special Industry	1.0540	1.7903	44.59

NOTE: Type I and Type III Multipliers are per dollar of direct sales;
Employment Multipliers are per million dollars of direct sales.

Government and Special Industries to $2.3106 for Poultry and Egg Production. The unweighted average of Type I Output Multipliers for all industries was $1.4518. Type III Output Multipliers ranged from $1.2435 for Motor Vehicles Manufacturing to $3.7978 for Fruits. The unweighted average of Type III Output Multipliers for all industries was $1.9603.

The 14 primary agricultural production industries (Industry 1 through Industry 14) tended to have larger than average multipliers (Table 2). Thirteen of the 14 sectors had Type III Multipliers that were greater than the state average. Nine of the 14 sectors had employment multipliers that were larger than the average state employment figure. All three multipliers for Dairy Farm Products, for example, were larger than the respective state averages. Sugarcane Production's Type I Sales Multiplier was slightly less than the state average (Table 2). But the sector also had a Type III Sales Multiplier of 2.7353 and an Employment Multiplier that were larger than the state averages.

Multipliers for the 19 agricultural processing sectors (Industry 24 through Industry 40) showed no pronounced trend relative to average values for all industries (Table 2). The majority of the food processing sectors had Type I Output Multipliers that were larger than the state average. But only nine sectors had Type III Multipliers that exceeded the state average. Four sectors had larger than average Employment Multipliers. Multiplier results for Processed Fish and Seafood were typical. The sector had a Type I Sales Multiplier and Type III Sales Multiplier that were both slightly larger than the state averages. But the Employment Multiplier of slightly less than 23 jobs per million dollars of gross output was less than the state average.

Multipliers for food processors differed partly because some Louisiana food processing sectors, such as Sugar Milling, exclusively process Louisiana agricultural products while others, such as Roasted Coffee, primarily process agricultural imports from other states or foreign countries. Processors that relied on Louisiana inputs tended to have larger multipliers because of these strong backward linkages with Louisiana farming. Still other food processing industries may process a mixture of Louisiana products and imported agricultural products.

Impact Analysis for Agricultural Industries

Another use to which input-output models can be applied is impact analysis. Impact analysis shows the effect of a particular change in final demand for a given set of industries on total economic activity in the economy being modeled. Impacts are calculated by multiplying the Leontief Multiplier Matrix by the appropriate set of changes in final demand. As such, impact analysis can be used to assess the effects of a given policy on a regional economy. It can also be used to assess the

contribution of a particular sector of the economy to total economic activity.

The state I-O model was used to estimate the impact of various parts of state agriculture on total economic activity in Louisiana. Model results can be interpreted as an estimation of the effect on total economic activity in the state if the set of Louisiana agriculture-based industries ceased to exist. Or, results can be interpreted as the total contribution of the set of industries to economic activity in Louisiana. Hence, the impact analysis was a gauge of the importance of the set of industries in question to the overall Louisiana economy when all direct, indirect, and induced effects were accounted for.

Impact analysis was done for the entire food production and food processing system in Louisiana as well as for the most important production agriculture and food processing sectors. As a simplifying assumption, economic activity in food and fiber processing was assumed to be dependent on Louisiana production agriculture. Hence, processing activity was generally assumed to cease to exist if the primary agricultural production sectors to which it was tied stopped production. Such an assumption also means that the effects of processing out of state agricultural products were accounted for in model results.

Agricultural products such as food products usually receive further added value beyond the immediate processing stage before being sold to final consumers. Such activity is concentrated in the transporting, wholesaling, and retailing of agricultural products. These value added activities occur regardless of the origin of the product in question. That is, consumer demand in general exists at the retail level for agricultural commodities regardless of the location of production and immediate processing. Hence, if Louisiana production of all sugar products ceased, for example, consumer demand for sugar products would still exist. Sugar products produced elsewhere would, as a rule, satisfy this consumer demand, and economic activity in the transportation, wholesale, and retail industries would be unaffected. As a result, direct impacts were evaluated for the food processing and agricultural production sectors but not for transportation, retail, and wholesale sectors.[5]

Overall Impact of Louisiana Agriculture

The significant contribution of production and processing of agricultural products to the overall Louisiana economy in 1985 is shown in Figure 2 and Table 3 for TIO, in Figure 3 and Table 3 for GSP, and in Figure 4 and Table 3 for employment. According to the Louisiana

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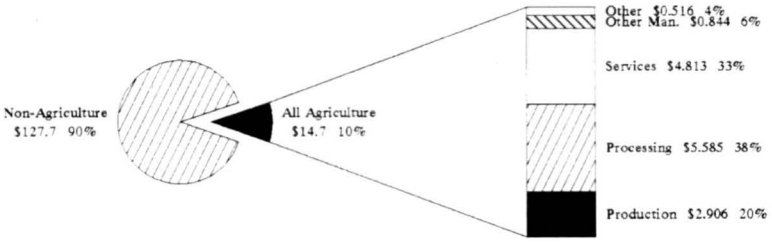
[5]Impacts that occur in retail, wholesale, and transportation industries because of direct purchases through such sectors by agricultural producers or food processors are accounted for through a process called margining. For more detail on margining see Miller and Blair (1985).



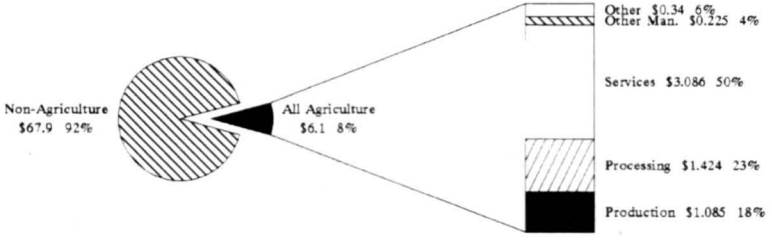
Total Industry Output

Composition of Agriculture TIO

Percentages add to more than 100% due to rounding error.

Billion 1985$. Construction, Mining in Other. Transportation, Communication, Government, Other Services in Services.

Figure 2. Louisiana Agriculture Contribution to Total Industry Output (TIO) Level and Makeup, 1985.



Gross State Product

Composition of Agriculture GSP

Percentages add to more than 100% due to rounding error.

Billion 1985$. Construction, Mining in Other. Transportation, Communication, Government, Other Services in Services.

Figure 3. Louisiana Agriculture Contribution to Gross State Product (GSP) Level and Makeup, 1985.

Table 3. Overall Contribution of Agriculture to the Louisiana Economy by Major Industry Group in 1985

Industry Number and Name	Total Industry Output (TIO)	Gross State Product (GSP)	Total Employment
	(Million 1985 $)		
1 Dairy Farm Products	119.101	59.141	6962.3
2 Poultry and Eggs	275.156	60.426	5864.7
3 Cattle	182.134	29.999	2701.2
4 Other Livestock	67.828	13.785	1301.9
5 Cotton	243.585	85.252	6414.4
6 Rice, Other Food Grains	159.604	80.445	5663.1
7 Feed Grains	74.282	16.822	1520.9
8 Hay and Pasture	28.792	5.910	528.8
9 Other Agriculture	11.563	2.788	539.2
10 Fruits	14.731	8.356	1842.2
11 Vegetables	34.366	14.302	2351.0
12 Sugarcane	169.863	93.013	11366.7
13 Soybeans	238.453	115.116	4899.1
14 Forestry	127.025	64.550	1343.4
15 Commercial Fishing	27.091	9.549	438.9
16 Agricultural Services	178.173	99.806	8329.0
17 Metal Mining	0.064	0.012	0.3
18 Other Nonmetallic Mining	4.645	2.484	58.1
19 Oil and Gas Extraction	367.817	273.485	1582.4
20 General Building Construction	0.000	0.000	0.0
21 Heavy Contract Construction	0.000	0.000	0.0
22 Repair, Maintenance Construction	98.997	46.398	3063.9
23 Fabricated Metal Products	18.008	7.857	221.7
24 Meat Packing, Preparation	160.706	25.630	1244.4
25 Poultry and Egg Processing	201.935	30.686	1889.0
26 Milk, Other Processed Dairy	400.370	96.182	2332.6
27 Processed Fish and Seafood	138.080	25.440	1498.4
28 Other Canned, Frozen Products	128.429	29.574	963.1
29 Canned Fruits, Vegetables	74.141	20.972	431.1
30 Bread and Related Products	257.830	104.549	3486.0
31 Other Processed Fats, Feed	312.440	58.036	1266.7
32 Rice Milling	201.656	32.366	1048.6
33 Sugar Milling and Refining	817.012	143.046	4948.3
35 Beverages	512.487	144.762	3868.6
36 Cottonseed Oil Mills	48.764	8.729	157.3
37 Soybean Oil Mills	65.398	3.229	54.9
38 Roasted Coffee	503.448	72.075	876.2
39 Miscellaneous Food Processing	97.100	33.858	1112.6
40 Textiles	10.932	4.233	210.2

Table 3. (continued)

41 Apparels	33.305	11.608	989.8
42 Lumber	981.401	334.840	12953.0
43 Furniture	3.718	1.383	62.6
44 Paper Products	1665.28	594.432	12310.6
45 Printing and Publishing	56.719	29.441	847.0
46 Chemical Products	261.449	80.309	1105.1
47 Petroleum Refining	380.992	62.247	223.9
48 Rubber, Miscellaneous Products	0.631	0.239	7.9
49 Leather and Tanning	0.614	0.186	17.4
50 Glass, Stone and Clay	25.419	10.604	334.2
51 Primary Metal Products	1.364	0.445	11.7
52 Nonelectrical Machinery	10.244	5.528	126.0
53 Scientific Instruments	1.763	0.936	28.8
54 Other Electrical Machinery	20.652	7.105	171.1
55 Motor Vehicles	31.128	7.804	105.7
56 Other Transportation Equipment	3.241	1.710	44.7
57 Miscellaneous Manufacturing	1.837	0.829	22.5
58 Railroads, Commuter Transportation	85.512	52.004	1359.9
59 Motor Freight Transport, Warehousing	162.977	105.287	3488.4
60 Water Transportation	58.589	16.247	572.6
61 Air Transportation	37.043	17.358	412.4
62 Pipe Lines, Not Natural Gas	6.119	3.466	20.2
63 Transportation Services	10.261	6.572	230.0
64 Communications	131.815	90.981	1610.5
65 Electric, Gas, Sanitary Services	527.995	242.331	3134.5
66 Wholesale Trade	465.702	338.040	8551.8
67 Retail Trade Not Restaurants	689.699	435.284	25181.1
68 Other Finance and Insurance	262.572	138.034	6010.2
69 Real Estate	775.325	626.244	1789.2
70 Hotels and Lodging Places	57.454	36.736	2875.2
71 Personal Services	131.701	105.942	5879.9
72 Repair Services	141.102	73.051	2694.6
73 Business Services	199.748	150.865	7203.5
74 Legal Services	93.376	72.209	1654.7
75 Miscellaneous Services	51.819	33.420	1065.7
76 Eating and Drinking Places	272.170	141.351	8695.4
77 Amusement Services	39.827	20.434	1535.8
78 Health Services	448.775	272.299	14278.6
79 Educational Services	43.148	30.574	1893.0
80 Membership Organizations	41.977	23.156	646.2
81 Social Services	44.435	26.932	3930.9
82 Government, Special Industry	34.117	27.292	1368.2
Total	14665.020	6158.611	227825.2

Note: Sugar milling and sugar refining are reported as a single industry to avoid disclosing proprietary information.

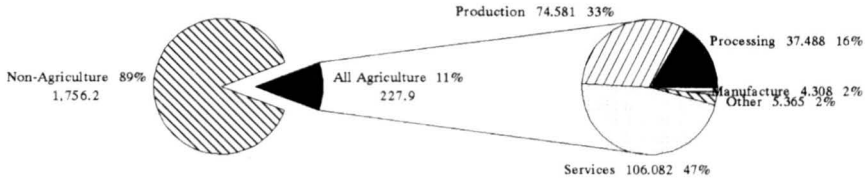


Figure 4. Louisiana Agriculture Contribution to State Employment Level and Makeup, 1985.

IMPLAN Model, TIO in the state economy in 1985 was slightly more than $142 billion (Figure 2). The direct, indirect, and induced effect of spending by agricultural industries was responsible for 10% or $14.7 billion of Louisiana TIO as shown in the pie in Figure 2. The processing of agricultural products was responsible for $5.6 billion or 4% of TIO in the Louisiana economy while production of agricultural products contributed $2.9 billion or 2% of Louisiana TIO.

The $14.7 billion contribution of Louisiana agriculture to state TIO can be subdivided based on major components of the economy as shown in the bar chart in Figure 2. Together production ($2.9 billion) and processing ($5.6 billion) of agricultural products formed $8.5 billion or 63% of the total impact of agriculture on the Louisiana economy in TIO terms. The production and processing of agricultural products were together responsible for $6.2 billion of TIO in other sectors of the Louisiana economy. This impact on other sectors was concentrated in Services, which had $4.813 billion of 33% of the total effect of agricultural spending. Manufacturing other than agricultural processing had $0.844 billion in TIO impacts.

Effects on the state economy in terms of Gross State Product (GSP) showed a similar impact (Figure 3 and Table 3). GSP in the Louisiana economy was estimated to be slightly more than $74 billion in 1985. The total impact on the Louisiana economy of agricultural production and processing was $6.1 billion of 8% of GSP as shown in the pie in Figure 3.

The $6.1 billion contribution of Louisiana agriculture to state GSP can be subdivided based on major components of the economy as shown in the bar chart in Figure 3. The production of agricultural products contributed $1.085 billion or 18% of the $6.1 billion GSP impact. The processing of agricultural products was responsible for an additional $1.424 billion or 23% of the agriculture-related Louisiana GSP. Spend-

ing in the production and processing of agricultural products was directly and indirectly responsible for $3.6 billion of GSP in other sectors of the economy. Like TIO, the spinoffs from agricultural activity in GSP terms were concentrated in Services, which had 50% of the total agricultural impact.

The composition of the contribution of agriculture to TIO and to GSP in terms of specific industries rather than broad components of the economy are shown in Table 3. Production agriculture sectors with larger than average contributions to GSP and TIO included Lumber with the largest contribution in terms of both measures as shown in Table 3. Soybean production generated $115.1 million of GSP and 238.5 million in TIO. Some production agriculture sectors differed in relative contribution to GSP and TIO in the Louisiana economy in 1985. For example, Poultry and Eggs was second among all production agriculture sectors in terms of TIO at $275.2 million. But the sector contributed less to GSP than a number of the other agricultural production sectors in the state economy. This difference in contribution to GSP and TIO indicated that expenditures by the poultry sector were concentrated in the purchase of material inputs such as animal feeds.

Paper Products was the largest agricultural processing sector in Louisiana in 1985 in terms of both GSP and TIO (Table 3). Other large contributions were made by Sugar Milling and Refining with $143.0 million in GSP and by Beverages.

Real Estate was the Louisiana service sector most influenced by agriculture-related spending in terms of both GSP and TIO (Table 3). Impacts on real estate generated small levels of employment in the state economy, however. Retail Trade not Restaurants had the second largest impact from agricultural spending among service sectors in both GSP and TIO. Like a number of other service sectors, impacts in both real estate and retail trade were mainly attributable to the induced effects of household spending. Other service sectors experiencing large impacts in terms of GSP and TIO included Electric, Gas and Sanitary Services, and Wholesale Trade.

Employment from the Louisiana IMPLAN Model also showed the important contribution of agriculture to the Louisiana economy. Agriculture was estimated to be responsible for 227,825 jobs in the state economy in 1985 or 11% of a total employment base of 1,984,000 jobs as shown in the first pie in Figure 4.

Impacts of agriculture were concentrated directly in the production and processing of agricultural products and indirectly in service industries as shown in the second pie in Figure 4. The processing of agricultural products was projected to be responsible for 37,500 jobs while the production of agricultural products accounted for 74,600 jobs. As shown in Table 3, the production and processing of sugarcane (sectors 12 and 33) and of wood products (sectors 14, 42, and 44) were responsible for

significant portions of the employment impact in both the production and the processing categories. For example, the Forestry and Lumber sectors were together projected to be responsible for 14,296 jobs while Paper Products were expected to be responsible for an additional 12,311 jobs. The number of Sugarcane producers and their employees were estimated at 11,367. Sugar Milling and Refining was estimated to have added 4,948 direct jobs to the Louisiana economy in 1985. Large impacts were also found in Beverages, Agricultural Services, and Cotton production.

The effect of agricultural processing and production had a large effect on other parts of the Louisiana economy. Spending generated by the production and processing of agricultural products was estimated to create 115,800 jobs in other portions of the Louisiana economy (Figure 4). These other employment impacts would be expected to come from the indirect and induced effects of spending generated by the production and processing of Louisiana agricultural products.

The composition of the total impact of agriculture on employment in the Louisiana economy is seen in Figure 4 and Table 3. Of interest was the relatively small effect of agriculture-related spending on other manufacturing in the Louisiana economy in 1985 with 4,308 total jobs (Figure 4). One important exception was the impact of agriculture on Louisiana Chemical Products as shown in Table 3. This impact reflected purchases of fertilizer and chemical pesticides by Louisiana farmers from chemical producers.

Service industries were especially affected by spending generated by the production and processing of agricultural products. The production and processing of agricultural products were predicted to indirectly create 106,082 jobs in service industries or 47% of the total impact (Figure 4). Impacts were concentrated in specific services, such as Retail Trade not Restaurants with 25,181 jobs, Health Services, and Eating and Drinking Places, as shown in Table 3. The large impact in these sectors was primarily due to the induced affect of spending by households where the primary breadwinner was employed in agricultural production or processing. Large job impacts were estimated for other service sectors, such as Business Services and Motor Freight Transportation and Warehousing. Impacts in these sectors were mainly due to their direct purchase by agricultural producers and processors or to the indirect effect of spending by agricultural producers and processors.

The contribution of Louisiana agricultural processing and production to the Louisiana economy was comparable in percentage terms to similar studies conducted for other states. Roughly 11% of all employment in the Louisiana economy was directly and indirectly attributable to agriculture. Carter and Goldman (1992) attributed 9.8% of all employment in the California economy in 1990 to spending generated by agricultural production and processing. Johnson (1994) included the entire marketing chain in his evaluation of the effects of agriculture on the Virginia

economy in 1991. He estimated that slightly less than 15% of employment in Virginia in 1991 was attributable to agriculture. Significant portions of these employment impacts were attributable to the effects of direct impacts in the distribution of agricultural products, which were excluded from this study.

Impact of Specific Agricultural Production and Processing Groups

Impact analysis was also done separately for the most important production agriculture and food processing sectors in the Louisiana economy. Values presented in Figure 5 and Figure 6 show the total effect of the selected set of agricultural production and processing industries on the overall Louisiana economy in 1985. Wood products, which includes all activity in the forestry, wood products, and paper products industries (sectors 14, 42, 43, and 44), had the largest impact on total economic activity in the state, accounting for 60,010 jobs, $4.681 billion in total sales, and over $2 billion in GSP (Figure 5 and Figure 6). The sugarcane production and processing sectors included all sugarcane production and milling as well as sugar refining in the state. The sugar sector accounted for over 32,500 jobs $1.855 billion in total sales, and $0.744 billion in gross state product. Dairy production and processing had $0.426 billion in GSP. Poultry and Egg production and related processing resulted in 17,815 jobs and $0.371 billion in GSP. Further, values reported here underestimate the **current** contribution of the

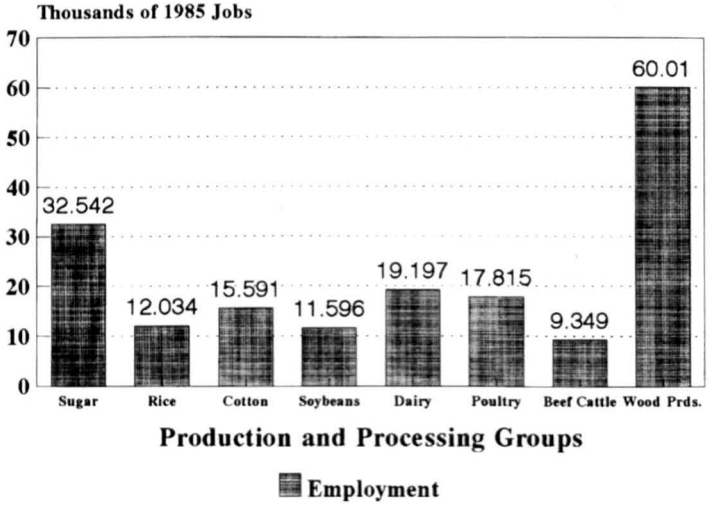


Figure 5. Impact of Selected Louisiana Agricultural Production and Processing Industries on Overall State Employment.

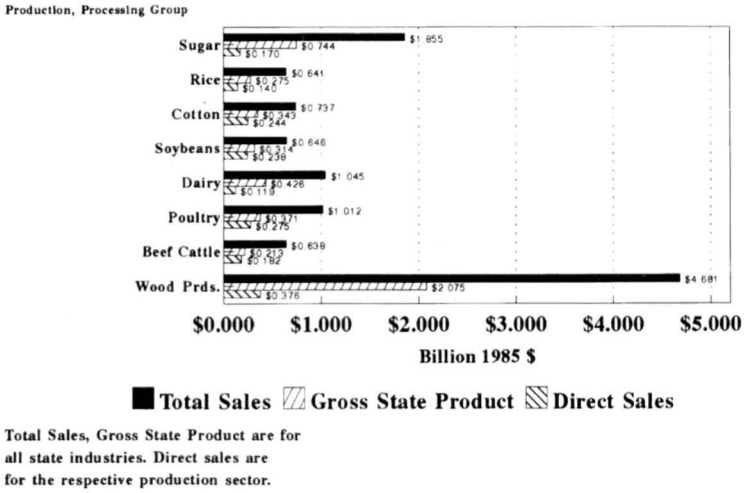


Figure 6. Impact of Selected Louisiana Agricultural Production and Processing Industries on the Overall State Economy.

poultry sector in all likelihood given the growth the sector has experienced in Louisiana since 1985.

The dairy, poultry, and beef impact scenarios showed relatively strong backward linkages for these production groups with other agricultural production and processing. Sectors involved in the production and processing of other agricultural products experienced 12% of the total employment effects of Poultry and Egg Production and processing or 2,146 jobs as shown in Figure 7 and Table 4. The effect was especially

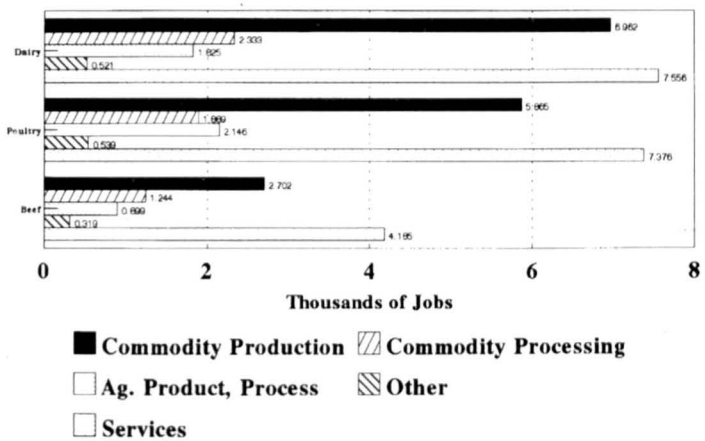


Figure 7. Distribution of Louisiana Jobs Tied to Processing and Production of Dairy, Poultry, and Beef in 1985.

Table 4. Total Effects of Poultry and Egg Production and Processing on Other Selected Louisiana Industries in 1985

Industry Number and Name	Total Industry Output (TIO)	Gross State Product (GSP)	Employment
	—— (Million 1985 $) ——		
2 Poultry and Eggs	275.154	60.425	5864.7
5 Cotton	3.152	1.103	83.0
6 Rice, Other Food Grains	0.685	0.346	24.3
7 Feed Grains	11.573	2.621	237.0
8 Hay and Pasture	0.368	0.076	6.8
13 Soybeans	5.956	2.875	122.4
16 Agricultural Services	24.615	13.788	1150.7
25 Poultry and Egg Processing	201.944	30.688	1889.1
31 Other Processed Fats, Feeds	55.548	10.318	225.2
58 Motor Freight Transport, Warehouse	6.132	3.961	131.3
64 Electric, Gas, Sanitary Services	28.735	13.189	170.6
65 Wholesale Trade	27.312	19.825	501.5
66 Retail Trade Not Restaurants	51.790	32.686	1890.9
67 Other Finance and Insurance	17.467	9.182	399.8
69 Hotels and Lodging Places	4.249	2.717	212.6
70 Personal Services	10.159	8.172	453.6
71 Repair Services	9.061	4.691	173.0
72 Business Services	9.324	7.043	336.3
73 Legal Services	6.498	5.025	115.2
75 Eating and Drinking Places	20.288	10.537	648.2
76 Amusement Services	3.408	1.749	131.4
77 Health Services	36.866	22.369	1172.9
78 Educational Services	3.319	2.352	145.6
80 Social Services	3.472	2.105	307.2
Total for All Industries	1012.444	371.292	17814.9

pronounced for Agricultural Services, which had 1,151 jobs and directly and indirectly generated by spending by poultry producers and processors. Other agricultural production and processing sectors especially influenced by spending from poultry and egg production and processing included Feed Grains (237 jobs), Soybeans, and Other Processed Fats and Feeds.

Other sectors involved in agricultural production and processing had 9.5% (1,825 jobs) of the employment impacts of the dairy impact scenario and 9.6% or 899 jobs of the total impacts of the beef impact scenario as shown in Figure 7. Effects in other agricultural production and processing sectors for the dairy scenario and the beef scenario were

concentrated in Feed Grains, Hay, and Pasture as well as Agricultural Services. The dairy impact scenario also had a large effect on the Cattle Industry and Other Livestock Industry.

Model results point out the importance of the processing sectors to the state economy. Soybean growers, for example, generated higher total direct sales than did dairy producers or sugarcane farmers. But unlike soybeans, both sugarcane and dairy products receive significant amounts of processing in Louisiana. Processors directly contribute to the value of Louisiana agricultural production, make purchases from other Louisiana firms, and make payments to households that support additional economic activity in the state.

In terms of employment, the IMPLAN model predicted that 4,955 individuals were involved in soybean production in Louisiana in 1985 as shown in Figure 8. An additional 6,642 jobs, only a small fraction of which were in soybean mills, were affected by that sector, or 1.356 "indirect" jobs were generated per job in the soybean production sector itself. On the other hand, 11,368 farmers and their workers were predicted to be employed in sugarcane farming (Figure 9 and Table 5). An additional 21,174 jobs, the sum of processing (4,949 jobs), other (484 jobs), other manufacture (1,083 jobs) and services (14,658 jobs) as shown in Figure 9, were linked to sugarcane production. Or 1.863 "indirect" jobs were created per job in the sugarcane production sector itself.

Results presented in Table 5 show changes in the level of economic activity in the state economy if sugar production and processing ceased. Similar patterns of effects across all industries were seen in impact

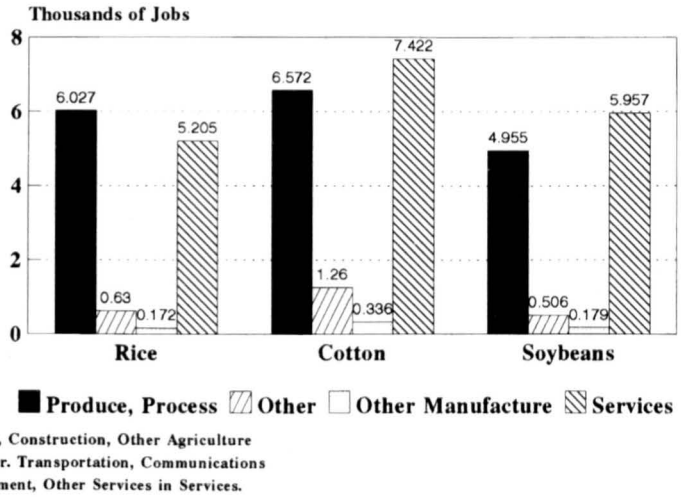


Figure 8. Distribution of Louisiana Jobs Tied to Processing and Production of Rice, Cotton, and Soybeans in 1985.

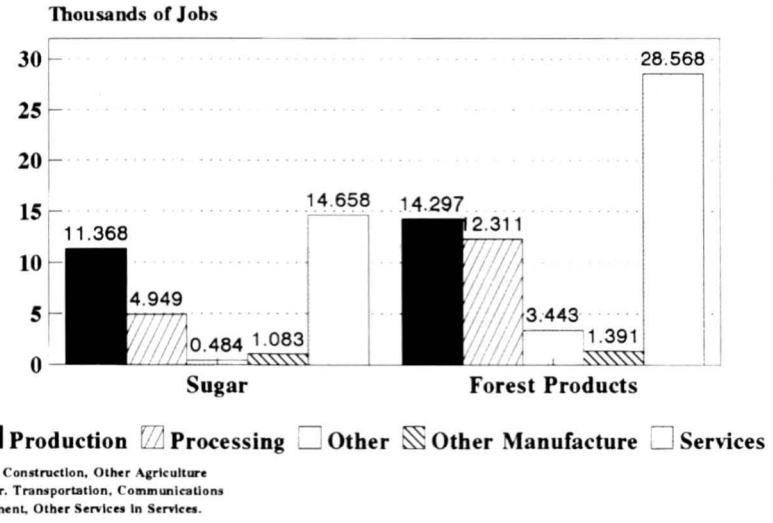


Figure 9. Distribution of Louisiana Jobs Tied to Processing and Production of Sugar and Wood Products in 1985.

Table 5. Total Effects by Sugar Farming and Processing on All Other Industries for Louisiana in 1985

Industrial Groups	Total Industry Output (TIO)	Gross State Product (GSP)	Employment
	(Million 1985 $)		
Other Agriculture and Related	9.476	3.668	306.1
Sugarcane 12	169.882	93.023	11368.0
Mining	60.611	44.971	264.5
Construction	10.870	4.808	336.4
Other Food Processing	24.068	6.577	187.5
Sugar Milling, Refining 33	811.102	143.061	4948.8
Other Manufacturing	99.690	25.079	471.9
Transport, Utilities	143.844	74.984	1438.0
Wholesale 65	53.208	38.622	977.1
Retail Trade Not Restaurants 66	96.196	60.974	3585.2
Finance, Insurance, Reality	150.789	108.985	1282.9
Other Services	157.183	97.510	5176.7
Health Services 77	63.588	38.583	2023.2
Government Enterprises	4.369	3.395	175.2
Total	1854.876	744.240	32541.5

Note: Industry number is given for industrial groups that are a single industry in the original 81 industry impact analysis.

analysis for other agricultural industries in Louisiana. Impacts were most heavily concentrated in the agricultural industries experiencing the decrease in sales, with sugarcane production and processing experiencing slightly over 51% of all job impacts. But service and trade industries in the state would have also been detrimentally affected by the cessation of activity in the sugar industries. Sugarcane farming and sugar milling and refining supported 3,580 jobs in retail trade and over 2,000 jobs in health services.

Model results showed a similar trend for the seven other scenarios with the impact in services being an important component in all cases. Services, defined here to include transportation, communication, government, and other services, experienced the largest percentage impact in the soybean scenario of 51% and the smallest percentage impact in the dairy scenario of 39%. The largest impact on service sector jobs in absolute terms was 28,568 jobs under the forestry scenario while the smallest service sector impact was for the beef scenario with 4,185 jobs (Figure 6 and Figure 7).

The relatively large impacts in trade and service activity demonstrated the importance of the induced effects of household spending based on payments to employees of agricultural industries. For the sugarcane production and processing scenario shown in Table 5, the induced effect of household spending was responsible for over 83% of the job impacts in other services and virtually all health services impacts.[6]

Much of the service industry employment impact from the sugarcane scenario and from the other agricultural impact scenarios would be expected to occur in urban areas of Louisiana. For example, analysis of unpublished Louisiana employment data (Louisiana State Department of Labor) showed that 82% of hospital employment was in parishes classified as urban by the U.S. Department of Commerce. The induced effect of household spending due to money interjected into the Louisiana economy by agriculture on so-called higher order services would primarily be felt in urban areas. Spending on advanced medical procedures by households directly and indirectly supported by agriculture would also by and large occur in urban areas.

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[6]For any given impact scenario, IMPLAN separately generates reports of direct, indirect and induced impacts. The separate reports were to estimate the induced impact as a percent of the total impact.

Summary and Conclusions

I-O analysis is a useful tool for gauging the importance of various agricultural production and processing firms to the state economy. A hybrid Input-Output table was constructed by modifying the Louisiana IMPLAN model for 1985 using data more representative of local conditions. The hybrid IMPLAN Input-Output model was used to estimate the effects of the entire agricultural production and first-line processing system on the Louisiana economy and to calculate multipliers for 82 industries. The model was also used to estimate the impact of selected agricultural industries on the state economy.

Multipliers derived from any input-output model are upper bound estimates of the potential economic activity generated by a particular sector of an economy. Multipliers presented here provide an indication of the potential for agricultural production and processing sectors to generate spinoffs in other parts of the Louisiana economy.

Although care should be taken in interpreting the model, impact analysis results indicate that agriculture is responsible for substantial levels of economic activity in Louisiana. Model results showed that on a relative basis, the contribution of Louisiana agriculture to state economic activity was comparable to agriculture's contribution to economic activity in California and Virginia. The production and processing of wood products and sugarcane both had especially large impacts on Louisiana economic activity. Processing of agricultural production and the induced effect of household spending supported by agricultural firms are especially important parts of agriculture's impacts. A substantial degree of such spending was expected to occur in Louisiana cities.

Finally, a study of the impacts of a specific policy on the Louisiana economy is beyond the scope of this study. Yet the model presented here could serve as device for evaluating the effects of a particular policy, such as a particular change in agricultural environmental regulations, on general economic activity in Louisiana.

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APPENDIX ONE: BASIC CONCEPTS IN INPUT-OUTPUT ANALYSIS

One view of product flows is to consider purchases that a particular industry makes from other regional industries for use in the production of its output. Such purchases of productive inputs are termed **backward linkages**. Because of within region backward linkages, an increase in the output of a firm causes an increase in its demand for other goods and services produced in the region.

Another view of the same process is to examine the sales that a given industry makes to other sectors (industries) in the economy. For example, vegetables are a product of the agricultural sector of an economy, but the vegetable canning and preserving sector of the economy uses vegetables as an input. A vegetable producer has **forward linkages** in that an increase in output results in increased supply of vegetables that is used by other industries in their production process. By increasing the supply of vegetables, the farmer may make it profitable for the vegetable processor to purchase more raw product. The processor will then pass the additional quantities to retail outlets that will sell the increase to final consumers.

An input-output flow table (matrix) provides a means of viewing the backward and forward linkages between various industries and agents in an economy in a given year (Appendix Table 1). The flow table contains several major parts. The interindustry portion of the table describes relationships between industries as buyers and sellers of products. The

Appendix Table 1. Flow Table for Hypothetical Regional Economy

	Interindustry Industry 1	Interindustry Industry 2	Final Demand: House-Holds	Final Demand: Capital	Final Demand: Exports	Total Receipts
Interindustry:						
Industry 1	150	500	100	100	150	1000
2	200	100	200	0	1500	2000
Value Added:						
Labor Payments	300	700	200	0	100	1300
Capital Payments	100	0	0	0	0	100
Imports	250	700	800	0	0	1750
Total Payments	1000	2000	1300	100	1750	

value added part of the table shows sales to industries by factors of production such as labor or owners of capital. The final demand section of the table shows sales by industries to final users of the product including households in the region, various types of government, and domestic and foreign export markets.

For all industries in the input-output flow table, the entry in each row describes the distribution of sales by the represented industry, i.e., it indicates all forward linkages. In the interindustry portion of the table, any particular cell shows sales for the industry represented in the row to the industry represented in the column. For example, in the hypothetical flow table shown in Appendix Table 1, the first row shows sales by industry one to itself of $150 million and sales from industry one to industry two of $500 million for the year in question. The final demand portion of the table indicates purchases by households and other final demand consumers of regional industry production. Therefore, continuing across the row, households in the region purchased $100 million dollars worth of goods from industry one. Industry one also had sales of $100 million to purchasers of capital products, such as equipment and buildings, and exported $150 million worth of output to firms, consumers, and governments outside of the region.

Reading down a particular column in the flow table indicates the backward linkages from the industry represented in the column to other elements of the local economy. Looking at the first column of numbers in Appendix Table 1, purchases of $150 million are made by industry one from itself and $200 million worth of purchases by industry one from industry two. The value added portion of the table shows interaction between industries and the primary factors of production. For example, industry one purchases $300 million worth of labor in the year of analysis as well capital, the only other primary factor of production in this simple example. Finally, industry purchases from firms outside the region (regional imports) are also added at the bottom of the table.

Backward linkages in the flow table can also be used to trace product movements and transformations in the economy. Consumers demand a product (say a food product), which in turn causes an increase in demand for the output of the food processing sector, which in turn causes an increase in demand for the output of the agricultural sector, which in turn causes an increase in demand for agricultural inputs, and so forth. It is through such backward linkages that an I-O model captures the multiplier effect of changes in activity in a particular industry on the entire regional economy.

An I-O table is derived from the flow table by column normalizing the matrix. That is, for each industry in the economy, each entry in the interindustry portion of the flow table is divided by the sum of industry purchases (from all other industries, from value added components, and from imports) with the results shown in Appendix Table 2. Inputs are

Appendix Table 2. Input-Output A Matrix for Hypothetical Regional Economy

		Industry	
		1	2
Industry	1	.15	.25
	2	.20	.05

now calculated on a per dollar of output basis by the purchasing industry. For example, an increase in output by industry one of one dollar causes a $0.20 increase in output for industry two.

An I-O matrix (table) can be manipulated to construct the Leontief Inverse or I-O multiplier matrix through simple matrix algebra. The sum of any column in the I-O multiplier matrix shows the total change in economic activity across all industries for a one dollar change in final demand for that particular industry. Because the I-O multiplier matrix is derived from the input-output model of that economy, it reflects the strength of internal backward linkages in capturing the multiplier effect of changes in spending in the local economy. Change the basic I-O model and the numbers generated by the I-O model (the Leontief Inverse) will also change. For example, the I-O multiplier matrix for the hypothetical regional economy shown in Appendix Table 3 was generated from the I-O model (Appendix Table 2) that was in turn based on the I-O flow model (Appendix Table 1).

The values shown in the I-O multiplier matrix are interpreted by reading down the column. The value in any cell of the matrix indicates the total effect of changes in sales by the local industry represented by the column on output for the local industry represented by the particular row. For example, the value 1.2541 in the first cell of Appendix Table 1 shows the total increase in output of industry one (represented by the first row in the table) that must occur if sales of that same industry (represented by the first column) increase by one dollar.

Imbedded in the value in the first cell in Appendix Table 3 are the direct and indirect effects on industry one of an increase in its own output. The direct effect is the immediate increase in industry output that must occur if industry sales increase by one dollar. Also contained in the cell is the indirect effect caused by industry one purchases from local industries (including itself) in producing its one dollar of output. The indirect effect exists because these other industries must increase their production, which in turn leads to additional purchases in the local economy on their part. Hence, in cell 1 of Appendix Table 3, the indirect effect is slightly over 25 cents meaning that over 25 cents of indirect (multiplier based) increases in output by sector one are required to support the original one dollar increase in its output.

Appendix Table 3. Input-Output Multiplier Matrix (Leontief Inverse) for Hypothetical Regional Economy Open with Respect to (Not Including) Household Spending Effects

		Industry 1	2
Industry	1	1.2541	.3300
	2	0.2640	1.1221
Column Sum		1.5181	1.4521

The increase in output by industry one will also have a purely indirect effect on the production of industry two. In the first column of Table 3, it can be seen that a one dollar increase in output by industry one will ultimately cause an increase in the output of industry two of more than 26 cents. The column summation shows the total change in output for all industries in the economy for a one dollar change in sales by industry one or a multiplier effect of $1.5181 in this case.

The hypothetical model presented in Appendix Table 3 ignores the effect of household spending supported by payments to labor that is a major component of regional impacts. The effect of household spending is included (i.e., the model is closed with respect to household spending) by treating it as another industry. Such treatment results in a TYPE II Leontief Inverse as shown in Appendix Table 4 based on the original flow table. Note the increase over the previously discussed TYPE I Multipliers shown in Appendix Table 3 where the effects of household spending are ignored.[7]

Appendix Table 4. Input-Output Multiplier Matrix (Leontief Inverse) for Hypothetical Regional Economy Closed with Respect to (Including) Household Spending Effects

		Industry 1	2	3
Industry	1	1.3639	0.4270	0.1848
	2	0.4079	1.2492	0.2422
	3	0.8031	0.7094	1.3518
Column Sum		2.5749	2.3856	1.7788

[7]IMPLAN generates Type III Multipliers rather than Type II Multipliers that show the effect of household spending on the regional economy. Type III Multipliers account for the effects of household spending based on assumptions about spending and migration patterns. For more detail, see Alward et al. (1989)

APPENDIX TWO: CONSTRUCTION OF THE LOUISIANA I-O MODEL

Hybrid and Ready-Made Input-Output Models

Research in the area of regional impact analysis has undergone a small explosion in recent years. A major reason for growth in this area is the increasing availability of ready made input-output modeling systems. Such systems facilitate construction of nonsurvey input-output models for a given region or community by providing access to databases and model construction techniques within a single computer software package. The accessibility of these models was greatly enhanced during the 1980s with the advent of the microcomputer. Coupled with the potential usefulness of the information generated from such models, this accessibility has led to a substantial increase in their use in drawing inferences concerning various policies and the overall structure of regional economies. One of the most widely used ready made model building procedure is the IMpact PLANning (IMPLAN) system, developed by researchers at the U.S. Forest Service (Alward et al. 1989).

Adapting ready-made models to a variety of uses has given rise to a group of input-output models known as "hybrids" (Jensen and West 1980). Hybrid models are input-output models that have been constructed for a specific purpose or economy by adapting one of the ready made models. Such adaptations are the result of efforts on the part of users to validate the model for a specific locale or use. Many different procedures are employed in the validation process ranging from the use of secondary and primary data sources to statistical procedures. The significance of these validation processes is especially sensitive to the level of sector aggregation employed in the model and the economic structure of the economy being modeled. These factors are particularly important to those concerned with substate or rural economies, since all of the ready made modeling systems draw on nationally developed coefficients.

Ready-made input-output modeling systems at best facilitate sorely needed regional analysis and at worse serve as a means of building inaccurate models that yield misleading results. In the ready-made modeling approach, regional input-output relationships are deduced from the national input-output table by a variety of mechanical methods. For example, a combination of regional purchase coefficients and Leontief production coefficients from the national input-output model are used in the IMPLAN model building system to calculate regional input coefficients (Alward et al.).

Ready-made models can be expected to yield reasonably accurate results if the economic structure of the regional economy is sufficiently

close to the national economic structure (Jensen 1987). The structure of important industries within the region may, unfortunately, tend to deviate from the national norm, however (Jensen). In such situations, ready-made models may provide a quick yet inaccurate and uneducated response to the need for empirical analysis of economic events by non-specialists unfamiliar with the use of interindustry models (Miernyk 1987).

Hybrid models also allow secondary employment and production data specific to the region to be combined with benchmark input-output data for the national economy for estimation of a regional input-output model. But hybrid models differ from pure ready-made models by allowing for the incorporation of specific data and information about the economy of the given region (Brucker et al. 1987). The construction of a hybrid model may also be considered an ongoing process since researchers can continue to improve model accuracy and extend model applications through the use of additional data sources and improved knowledge of the specific economy (Greenstreet 1989). Users of the approach aim to retain the cost and time savings of ready-made models while approaching the accuracy of survey-based models.

The Louisiana Hybrid IMPLAN Model

The IMpact analysis for PLANing (IMPLAN) model building procedure was used to construct a preliminary I-O model of the 1985 Louisiana economy. In IMPLAN, regional models at the state or substate level are constructed by applying regional data to the U.S. I-O model. Among other information, estimates of regional total sales, final demand, returns to factors of production, and employment were generated by IMPLAN for up to 528 industries in the state economy.

The preliminary I-O model was then refined based on a variety of data sources and expert opinion concerning economic linkages in the state economy. This process of model verification and improvement resulted in a hybrid I-O model of the 1985 Louisiana economy. The year of analysis was 1985 because at the time the study was instigated, it was the most recent available IMPLAN data. Conditions in 1985 were assumed to be sufficiently equivalent to current conditions to allow for applications of the model.

Verification and, when necessary, alteration of data in the original IMPLAN model occurred in three distinctly different ways. New estimates of total industry output, the components of value added, and employment were made for all industries in IMPLAN. New estimates were necessary because data used in the IMPLAN model were not the latest updated figures for 1985 and did not provide the most accurate picture of the Louisiana economy. For example, total earnings in the state economy were estimated at $43.8 billion in the original IMPLAN

model while the latest estimates of earnings were $37.2 billion for the Louisiana economy in 1985.

Several data sources were instrumental in making new estimates of total industry output, the various components of value added, and of employment. Louisiana earnings (employee compensation plus proprietors' income) data for 1985 at the two-digit level of the Standard Industrial Classification published in the Regional Economic Information System (REIS) (U.S. Department of Commerce, Bureau of Economic Analysis) were used in the adjustment process. Employment data at the SIC Code one-digit level from the REIS system and unpublished employment data for 1985 at the SIC Code three-digit level, obtained from the Louisiana Department of Employment Security, were used in reestimating employment for state industries.

Employee compensation and proprietors' income are the two components in the REIS earnings data that formed the basis for changes in total industry output and value added at the industry level. Employment compensation and proprietors' income were summed for two-digit SIC Code aggregations of IMPLAN industries. The REIS earnings data at the two-digit SIC Code level were then compared with earnings as found in the original IMPLAN ready made model at the two-digit level. The ratio of REIS earnings estimates to IMPLAN earnings estimates was then used in adjusting the two components of earnings as well as total value added and total industry output for the appropriate IMPLAN sectors.

Separate estimates of the two components of earnings, employee compensation and proprietors' income, were not available in the REIS data at the two-digit SIC Code level. But the REIS data did contain total employment compensation and total proprietors' income for all private firms and government entities in Louisiana in 1985. These totals suggested that the procedure of data calibration in obtaining consistency with the REIS earnings data resulted in an under estimate of total employment compensation of 1.25% and an over estimate of total proprietors' income of 7.18%. Consistency with these totals as well as with the two-digit level SIC Code earnings data was obtained through a RAS (a biproportional matrix adjustment procedure) (Miller and Blair 1985). The RAS procedure proportionally adjusted employment compensation upward and proprietors' income downward in obtaining consistency between total employee compensation and total proprietors' income summed over all industries versus earnings at the two-digit SIC Code level.[8]

Levels of total industry output and value added for seven major

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[8]In the model calibration process, proprietors' income for mining and real estate sectors were reestimated at higher values than those found in the REIS data set. In the production function calibration process, the majority of payments to the real estate sector by production agriculture was treated as proprietors' income.

production agriculture industries were calculated in a different fashion. Commodity output data for 1985 through 1989 were obtained from *Agricultural Statistics and Prices for Louisiana, 1985-1991* (Zapata and Frank 1992). Using the Consumer Price Index, the output data were deflated to constant 1985 dollars and total industry output was calculated as an annual average. All components of value added were then readjusted in line with the 1985 through 1989 average of total industry output. Similar adjustments were also made to total industry output and value added for the sugarcane milling and rice milling industries.

New employment levels for IMPLAN industries were based on unpublished data provided by the Louisiana Department of Labor and on the REIS data. Employment levels for all industries at the SIC Code two-digit level were revised for consistency with unpublished state data at the SIC Code two-digit level. While the Louisiana Department of Labor data provided more detail, the REIS data included employment excluded in the state data, primarily self-employed workers. As a result, employment included in the REIS data but not in the state employment data had to be allocated to the various IMPLAN sectors. A two-step process was used in which the difference between employment values from the Louisiana Department of Labor and REIS jobs at the SIC Code one digit level was calculated. The difference was used as a control total in allocating self employed and other omitted jobs to the various IMPLAN sectors based on the relative levels of employment calculated in the previous step.

Another major component of the calibration process was the calculation of production functions for regional industries. Production functions in IMPLAN are based on the assumption that the economy of the region in question and the national economy are the same in terms of input and output mix. For example, the production of sugar crops uses the input mix of a statistically average sugar farmer at the national level, which would include both sugar beets and sugarcane producers from various regions. As a result, estimates from the model may deviate considerably from model estimates based on practices of Louisiana sugarcane growers.

To rectify this problem, new production functions were obtained for a number of production agriculture and agricultural processing industries. Information derived from farm production budgets published by the Department of Agricultural Economics and Agribusiness (January 1990), Louisiana State University Agricultural Center, Louisiana Agricultural Experiment Station were used in constructing fixed proportions production functions for cotton, rice, soybeans, and sugarcane. Unpublished sources of information provided by researchers in the Department of Agricultural Economics and Agribusiness were instrumental in constructing production functions for soybean mills, cottonseed mills, sugarcane mills, and rice mills.

The last set of changes to the basic IMPLAN model concerned Regional Purchase Coefficients (RPC) that are estimated on a commodity basis. For any given commodity, the RPC is an estimate of the proportion of regional commodity demand that is met from regional commodity supply. The RPC is fundamental in determining the level of commodity imports and exports and as a result the strength of internal linkages in the Louisiana IMPLAN model.

According to IMPLAN estimates, 494 different commodities were produced in Louisiana in 1985 by 397 industries. RPC values were revised for 96 of these commodities. The RPC for 78 transportation, communication, banking, and service sectors in the IMPLAN model of Louisiana were problematic and were, therefore, replaced by values taken from Pedersen (1990). The RPC for 18 agricultural production and processed commodities were also revised based on the opinions of experts and published and unpublished data concerning economic linkages in the Louisiana economy.

The model was then aggregated from the 397 industries into 82 final industries to facilitate discussion of model results. The basis of the aggregation was the U.S. Department of Commerce, Bureau of Economic Analysis, 70-industry division of the U.S. economy. The BEA aggregation scheme was modified to highlight agricultural production and processing industries in the Louisiana economy. In some cases, the industry is a single industry in the original IMPLAN model such as Cotton (Aggregate Industry 5, IMPLAN Industry 10) and Hotel and Lodging Places (Aggregate Industry 70, IMPLAN Industry 471). Other industries are aggregations of the original IMPLAN industries such as Health Services, which is an aggregation of IMPLAN industries 503 through 506.

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Measuring the Effect of Louisiana Agriculture on the State Economy Through Multiplier and Impact Analysis

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